

GEOMORPHIC EVIDENCE FOR ANCIENT SEAS IN WEST DEUTERONILUS MENSÆ, MARS - I: REGIONAL GEOMORPHOLOGY

by

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Deuteronilus Mensae lies at the western end of a swath of fretted terrain greater than 500km wide and 3000km long comprising the boundary between the northern lowland plains of Mars and the topographically higher and more heavily cratered southern highland terrain from 30° to 50° latitude, 280° to 350° longitude. We will concentrate on the fretted terrain morphology within a specific region in west Deuteronilus Mensae (44° to 50° latitude, 342° to 347° longitude, figure 1).

The fretted terrain in west Deuteronilus Mensae consists of extensive cratered upland "penninsulas" or isolated plateaus cut by long, finger-like canyons typically 10 to 20km wide and upwards of 300km long. The longest of these canyons trend roughly north-south to north-northeast in much of the region depicted in figure 1, which may reflect some local structural and/or topographic control. Along the east side of figure 1, and throughout much of Deuteronilus Mensae, the lowland dissection of the cratered upland also exhibits some circular and arcuate trends that might indicate preferential degradation of buried large impact structures (1). This particular example of martian fretted terrain presents a relationship to the lowland/upland boundary which is unique in that the gross fretted terrain morphology, rather than defining the lowland/upland boundary as is the case for most martian fretted terrains, is in fact present on both sides of the boundary (though it is highly degraded on the north side).

At least three geomorphic zones roughly parallel to the lowland/upland boundary, suggestive of increasing modification northward, can be recognized on the fretted terrain of the region. These zones appear to be equivalent to what Weiss et al. (2) interpreted as stratigraphic units. For convenience of description we have identified these zones, from southern highlands to northern plains, as "A", "B", and "C".

The southern-most zone (zone "A") consists of sharply defined fretted terrain. The highland plateau surfaces generally appear brighter and more varied in albedo and texture than do those of the middle zone immediately to the north (Zone "B"). They are separated from the canyon floors by escarpments ranging from 262m (± 32 m) near the plateau surface contact with zone "B", to greater than 650m (± 32 m) toward the south edge of figure 1. (All shadow measurements for the canyon walls were measured from Viking Orbiter image 673B43, which covers this same region at a resolution of 204 m/pixel with a sun elevation of 9°). The canyon floors of zone "A" are comprised of smooth plains partially to completely buried by relatively bright debris aprons from the canyon walls. These debris aprons occur as sharply defined, gently sloping surfaces that are either concentric to isolated plateau outliers or parallel to canyon walls and are typically less than 10km wide. They occur at the bases of all fret escarpments within zone "A" except those within about 50km of the contact with zone "B" on the plateau surface. The contact between zones "A" and "B" is a well defined irregular line running east-west across the cratered upland surface and plateau outliers. This contact can be readily traced across the highland surface for several hundred kilometers, both to the southwest and east of the area shown in figure 1. On the lowland surface it is less easily recognized, particularly to the east, where the plateau outliers are more scattered.

The middle zone (zone "B") consists of well defined fretted terrain in which the plateau surfaces appear smoother, with a somewhat darker and much less varied albedo surface than those of zone "A". The canyon walls in zone "B" range in height from less than 64m (± 32 m) just north of the degraded 10km crater at D in figure 1, to as high as 163m (± 32 m) north of the plateau surface contact between zones "A" and "B". North of the crater at D, the canyon wall slopes approach that of the sun elevation, so heights cannot be determined reliably by shadow measurements. The canyon floors of zone "B" are comprised of smooth plains similar to those of zone "A", but lack the prominent debris aprons. Instead, much of the canyon floors adjacent to the escarpments either lack debris aprons entirely at this scale or, at best, exhibit poorly defined or subdued debris aprons expressed as narrow features (a few km or less wide) intermediate in slope between those of the canyon wall and floor.

The northern-most zone (zone "C") consists of rounded or "softened" fretted terrain. The plateau and canyon surfaces consist of light and dark "striped" terrain within about 50km of the contact with zone "B", and mottled terrain beyond about 50km from the contact with zone "B". Slope inflections at plateau/canyon margins within zone "C" are very subdued. On the plateau and upland surface, the contact between zones "B" and "C" is expressed as a moderately well defined line separating the smooth, relatively uniform albedo surface of zone "B" from the striped or mottled surface of zone "C". Within the fret canyons, the contact between zones "B" and "C" is somewhat sharper than it is on the plateau surface and is expressed as smooth arcs or lobes with their concave sides facing zone "C" (at E, figure 1). The plateau/lowland morphology typical of the fretted terrain, though

apparently highly subdued, is visible in this region as far north as 51° latitude, more than 200km north of the contact between zones "B" and "C" - approximately coincident with the usual position given for the boundary between the northern plains and the southern highlands (3,4).

Weiss et al. (2) interpreted the zones as surface exposures of successively lower stratigraphic units. In their model, these units are nearly horizontal layers intersecting the northward-dipping plateau surface. However, at least two problems with a stratigraphic interpretation for the zoning become apparent in the 200m/pixel images of figure 1. Such problems become even more apparent upon examination of very high resolution images (see footprints for these images on map, figure 1) of the region (5): (A) The northern limit of the occurrence of prominent debris aprons associated with zone "A" exhibits an apparently topographically conformal offset to the south with respect to the plateau surface contact between zones "A" and "B". If the debris aprons are associated with the wasting of an upper "A" stratigraphic unit, they should occur as far north as the plateau surface contact between zones "A" and "B". Also, the gradual decrease in height of the canyon walls to the north might expectedly produce progressively narrower debris aprons to the north. Further, if they are comprised of material from all three units, one might expect them to be found associated with escarpments in zones "B" and "C" as well. (B) The smooth, lobate contact between zones "B" and "C" (at F, figure 1) embays an old, degraded crater about 15km in diameter. A stratigraphic contact would have been disrupted by the formation of the crater.

Another, though provocative mechanism by which topographically conformal zone contacts might be produced on the fretted terrain is by successively lower levels of standing water associated with episodes of catastrophic outflow channel development elsewhere along the lowland/upland boundary. If the zone boundaries represent old shorelines, the above problems can be addressed: (A) The absence of prominent debris aprons in zones "B" and "C" could be due to reworking or complete removal of the debris by rising and falling water levels. The southward offset of the contacts between zones "A" and "B" and between zones "B" and "C" could be due to successive episodes of embayment of the canyons. (B) Embayment of the 15km degraded crater by the contact between zones "B" and "C" easily fits the expected behavior of a shoreline.

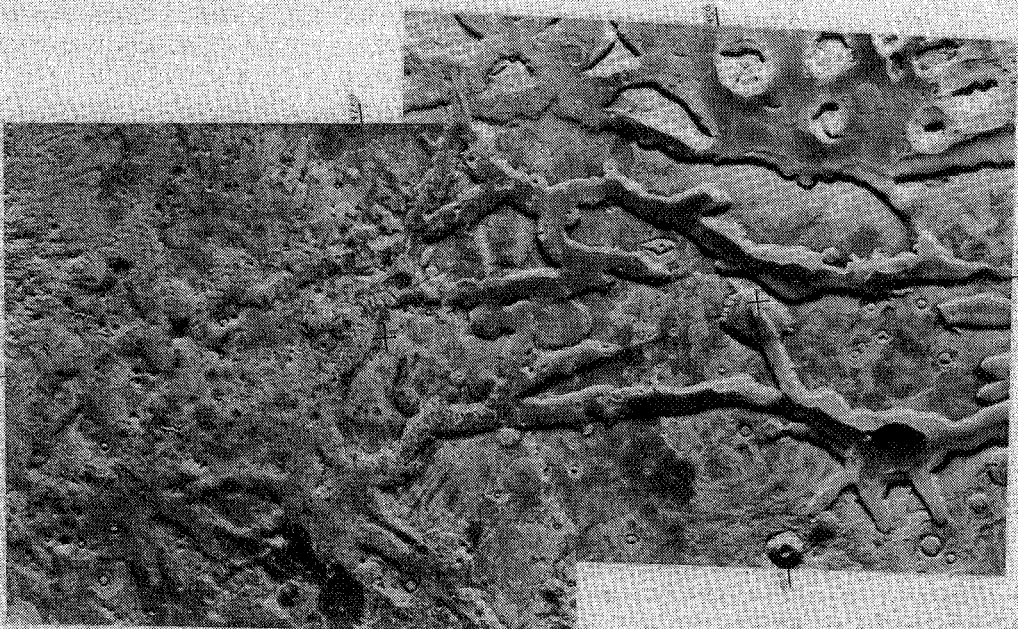
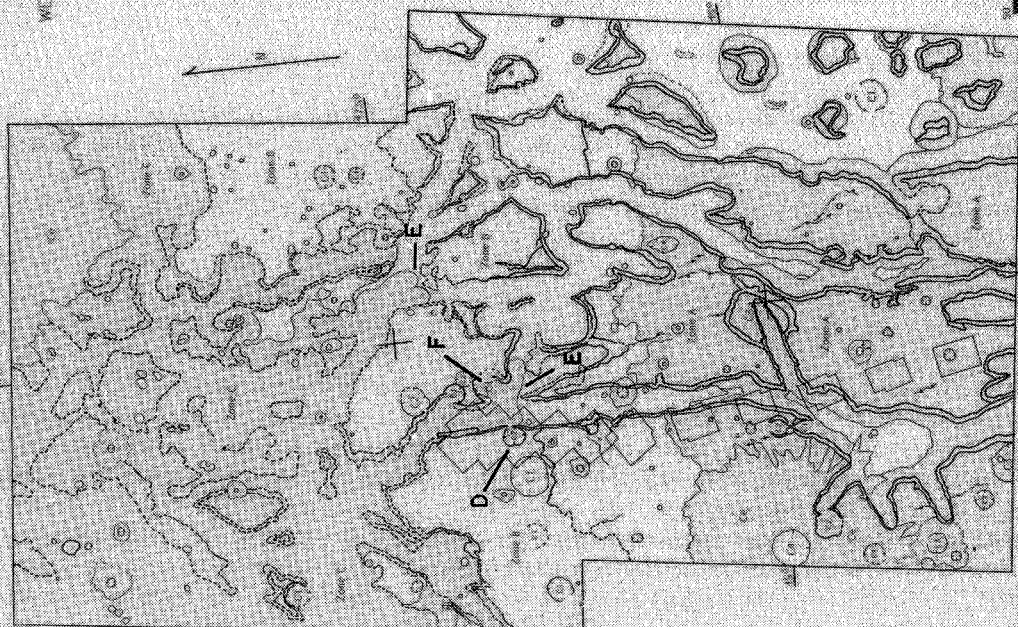
In addition to providing reasonable explanations for the above problems, successive levels of standing water within the northern lowlands might be useful in addressing some other fretted terrain problems. (A) Removal of debris (likely to be comprised of a wide range of grain sizes) wasted and/or sapped from the canyon walls in a near shore lacustrine environment would be efficient and could produce the smooth canyon floor surface without affecting the plateau surface (as might be expected of eolian processes). It also provides a very effective way of maintaining the steep cliffs by focusing erosion (through wave action) at the bases of the cliffs and, at the same time, preventing the accumulation of talus deposits.

References:

- (1) Sharp, R. P., 1973, Mars: Fretted and chaotic terrains: *Journ. Geophys. Res.*, Vol. 78, p. 4073-4083.
- (2) Weiss, D., Fagan, J. J., Steiner, J., and Franke, O. L., 1981, Preliminary observations of the detailed stratigraphy across the highland-lowlands boundary: Reports of the Planetary Geology Program - 1981, NASA Tech. Memo. 84211, p. 422-425.
- (3) Lucchita, B. K., 1978, Geologic map of the Ismenius Lacus Quadrangle of Mars: USGS Map I-1065, Atlas of Mars, 1:5,000,000 Geologic Series.
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Figure 1: Geomorphic Map of West Deuteronilus Mensae, Mars. Viking Orbiter Images: 675B34,59.

GEOMORPHIC MAP OF WEST DEUTERONILUS MENSAL, MARS



Explanation

Frontal Terrain Zones

Shaded relief Frontal Terrain Zones are defined by the following criteria: 1. The north-south extent of the zone is greater than 100 km. 2. The zone is bounded by a prominent topographic feature (ridge or depression) which is continuous across the entire zone. 3. The zone is bounded by a prominent topographic feature (ridge or depression) which is continuous across the entire zone.

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Crater Classification

Shaded relief Crater Classification is defined by the following criteria: 1. The diameter of the crater is greater than 10 km. 2. The crater is bounded by a prominent topographic feature (ridge or depression) which is continuous across the entire crater. 3. The crater is bounded by a prominent topographic feature (ridge or depression) which is continuous across the entire crater.

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